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OVERWINTERING MORTALITY OF DOUGLAS-FIR BEETLES IN INFESTED LOGS, EXPOSED BARK AND FOREST LITTER IN WESTERN WASHINGTON

by

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SUMMARY

Fifty-four per cent of adult Douglas-fir bark beetles overwintered successfully for 3 months in loose bark on the forest floor; 40% survived a similar exposure in the forest litter. Survival for beetles in the undisturbed bark of windthrown trees was 84%. Of a sampling of survivor beetles, both sexes were functional; female beetles laid viable eggs and constructed galleries. Survival of larvae subjected to overwintering in similar materials and on the same sites was of the same order of magnitude as for adult beetles. Surviving pupae, included only incidentally in the study, did not develop into adults. Beetle overwintering observations were made on four selected windthrown Douglas-fir trees and in adjacent screen-bags provided either with loose bark or typical forest-floor litter. In order to be most effective in removing bark-beetle broods from the woods, windthrown trees, right-of-way logs and other felled trees should be logged before the bark becomes loose enough to fall off during logging. The threat of tree killing by the beetle coupled with the deterioration loss are sound reasons for prompt removal of down timber from the woods.

INTRODUCTION

Removal of trees infested with Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopk.) before the beetles emerge in the spring was

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recommended long ago by Hopkins (1909) and Hopping (1921) as a means of control. Furniss (1959), however, pointed out that if logging is delayed too long, the bark loosened and knocked off during skidding and loading (Fig. 1) offers a continuing medium for beetle survival. On the other hand, some observers have assumed that logging results in high beetle mortality, despite the possibility of beetle survival in the bark left on the ground. These diverging opinions affecting sanitation measures have indicated the need for objective measurement of beetle survival over winter in available material. The study reported in this Research Note was exploratory, and designed to determine overwintering mortality of adult Douglas-fir beetles in the infested log, in bark removed from the log, and in forest litter. The study also included limited observations on mortality of larvae.

REVIEW OF PAST WORK

Pertinent information on overwintering mortality of the Douglas-fir beetle in the Rocky Mountains appears in a report by Bedard (1933), who found that adult beetles exposed over winter in bark sections suffered over 86% mortality. Miller and Keen (1960) reported only a slight increase in mortality of western pine beetles when infested bark slabs were buried in the soil for as long as 142 days. Kinghorn and Chapman (1959) reported that the ambrosia beetle, Trypodendron lineatum, normally overwinters in the forest litter. Slander (1958) found that the bark beetles, Ips typographus, Pityogenes chalcographus and Crypturgus cinereus, overwinter at least in part in the forest litter.

METHODS

Four infested Douglas-fir windthrows -- one old-growth and one second-growth on each of two Weyerhaeuser Company Tree Farms in Western Washington -- were selected at random from 16 candidate trees. On December 30, 1959, several completed Douglas-fir beetle galleries on each selected tree were examined and the number of living and dead Douglas-fir beetles counted. These counts provided a base for mortality calculations and indicated the bark area necessary to give approximately 100 living adults in each of the nine combinations of overwintering habitat and exposure time. These included three habitats of overwintering adults: (1) in bark adhering to the fallen tree bole (undisturbed bark)*, (2) in bark removed from the fallen bole

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* The term "undisturbed bark" is used consistently in the remainder of this Research Note to identify the portion of the study conducted on bark in place on the fallen bole.

Fig. 1. – Deck of recently skidded logs that had been infested with the Douglas-fir beetle 1 year earlier. Note the loss of bark.

(removed bark)**, and (3) in litter. For each of these three conditions, further counts were made after approximate exposure of 1, 2, and 3 months.

Each habitat-exposure treatment was set up in duplicate. In selection of galleries to be left on the down tree and those to be removed with the bark, twice the needed number were numbered. Half of these were then selected at random for exposure in the test. Sufficient bark to contain approximately 100 living adult beetles was removed and placed in bags made of 14-mesh lumite screen. One hundred living adults were placed in a similar screen bag filled with forest litter. The bags were labeled, closed, and placed on the forest floor close to the log from which the samples were taken (Figs. 2 and 3).

The first treatments were established on December 30, 1959, the second on February 14, 1960, and the third on March 23, 1960. All samples were brought into the laboratory on April 25 for analysis. Heavy snows prevented the setting out of treatments at precise 1-month intervals as intended. The "1-month" period of exposure referred to in this Research Note extended from March 23 to April 25; the "2-month" exposure from February 14 to April 25; the "3-month" exposure from December 30, 1959 to April 25, 1960. After exposure the bark slabs were completely dissected and the number of living and dead beetles recorded. The litter samples were passed through a "4-mesh" screen and the living and dead beetles counted. Living and dead larvae and pupae were tallied for both the undisturbed and the removed bark. Larvae were placed in the litter samples beside only one sample tree. The per cent mortality was used in an analysis of variance to detect differences among habitats or periods of exposure.

The method used to compute mortality was as follows: Mortality of beetles in the undisturbed bark for a given period of exposure was assumed to be the difference between per cent mortality at the beginning of the period and that at the end of the period. For example, the mortality in the undisturbed bark for the period February 14 - April 25, was the difference between the per cent mortality recorded on these two dates. In removed bark, however, the mortality for the same period was the difference between the mortality recorded in the undisturbed bark on February 14, and that found in removed bark exposed from February 14 to April 25. This computation was necessary to take into account the amount of mortality that had occurred in the bark before it was removed. Mortality in the litter was the actual per cent mortality occurring during a given period of exposure, since exactly 100 living beetles were placed in

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** The term "removed bark" is used consistently to identify the loose beetle infested bark used in the study.

Fig. 2. (ABOVE) – Plastic-screen bags containing infested bark (left) and forest litter (right).

Fig. 3. (LEFT) – Bags containing bark and litter beside infested logs in the field.

each bag at each sampling date.

Twenty beetles each from the litter and the exposed bark samples were drawn at random from a large number and tested for flight response. The description of response was the same as that used by Atkins (1959) except that "good" and "poor" were grouped as positive. The flight of beetles that merely expanded their wings and vibrated them insufficiently for flight, was classified as "flutter". If the elytra were not opened, the response was recorded as negative. As a control, an equal number of beetles that had overwintered in undisturbed bark was used. The beetles were warmed to room temperature and each tossed into the air. If no flight response was noted on the first toss, two additional tosses were made before recording response.

To see if beetles exposed over winter would construct galleries and lay eggs, pairs of beetles, that had been exposed 1 month and 3 months in the litter, 2 months in the removed bark or 3 months in the undisturbed log, were allowed to infest 2-inch-thick Douglas-fir slabs measuring 5 by 10 inches. Four pairs of beetles were used to represent each of the four overwintering conditions tested.

RESULTS

Beetles overwintering in either the forest litter or the removed bark suffered significantly greater mortality than those overwintering in undisturbed bark on the bole. During a 3-month period, a mortality of 16% occurred among the adult beetles on the undisturbed bole, nearly 46% in the removed bark, and 60% in the forest litter. Even over a 1-month period, greater mortality occurred in the exposed bark and litter than in the bole. Mortality increased very significantly with duration of exposure. A slight interaction occurred between overwintering habitat and time of exposure, indicating that at least one of the overwintering conditions varied significantly with some element other than time. From Table 1, it would appear that the mortality of beetles in removed bark was less in 2 months than in 1 month. This reversal is obviously a result of sampling error.

It was found that 66% of the adult beetles in second growth and 72% in old growth occupied the phloem region and were visible when the bark was removed. The remainder had bored into the bark. Hence, when bark is removed from logs during logging, one can expect some two thirds of the adults to fall to the ground. No significant difference was apparent between the amount of beetle mortality in second-growth and that in old-growth trees.

Although the primary interest lay in the adult stages, information was recorded for overwintering larvae and pupae. Table 2 indicates that the average mortality for all larvae samples

Table 1. - Effects of location and duration of exposure on mortality of overwintering Douglas-fir beetle adults.

Location	Duration of exposure			
	1 month	2 months	3 months	All
	Mortality per cent			
Undisturbed bark	8	9	16	11
Removed bark	38	33	46	39
Forest litter	22	58	60	47
All	23	33	41	32*

*Standard deviation = 11

Table 2. - Effects of location and duration of exposure on mortality of overwintering Douglas-fir beetle larvae.

Tree class	Location	Duration of exposure			
		1 month	2 months	3 months	All
		Mortality per cent			
Old growth	Undisturbed bark	9	6	15	10
	Removed bark	16	24	33	24
Second growth	Undisturbed bark	38	47	51	45
	Removed bark	22	35	65	41
	All	21	29	41	30*

*Standard deviation = 18

was of the same magnitude as that for adult beetles. Mortality increased significantly with duration of exposure to the conditions applied. Larvae overwintering in second-growth trees had a significantly higher mortality rate than those in old growth. Mortality differences between larvae overwintering in the bark and those overwintering on the trees were not significant. All of the larvae placed in the litter samples at the one location were dead after 1 month's exposure. Although a number of pupae found in the removed bark and in the undisturbed bark appeared to be alive, none developed into an adult when taken into the laboratory.

No significant differences in flight response were found among the beetles which had overwintered for 3 months under the three habitats studied. The average per cent response was: "positive" -- 74, "flutter" -- 20, and "negative" -- 6. Although the differences in respect of habitat were not significant, the highest positive response was made by the beetles overwintering on the log (90%), and the lowest by those beetles overwintering in the litter (62%). Overwintering treatment had no apparent effect upon sex ratio and average ratio was 1 female to 1.2 males.

Of the female beetles tested on slabs after overwintering, all constructed galleries and most of them laid viable eggs, indicating that both sexes were functional. Gallery lengths averaged 22.2 centimeters and larvae per gallery averaged 57. Overwintering produced no significant differences in respect of treatments, the number of larvae, or the length of the egg gallery. Figure 4 shows one of the test slabs with a gallery produced by a female beetle that had spent the previous 3 months in the forest litter.

DISCUSSION

The most important finding of this study is that about one-half of the adult bark beetles may overwinter successfully in exposed bark or, more surprisingly, in the forest litter. The mortality will probably vary with the severity of physical factors such as weather, stand density, soil moisture and degree of logging disturbance. Although the screen bags may have had some effect, tests showed no difference between the moisture content of the litter in the bags and that of the undisturbed litter. Microscopic examination also indicated that the soil fauna remained similar to that in natural litter. The larger insects, mammals, and other fauna were excluded by the screen bags.

This study did not attempt to answer questions regarding the trend of deterioration and loss of bark from logs. It was apparent, however, that a high percentage of the bark is lost when logging is delayed 6 to 9 months after the trees are

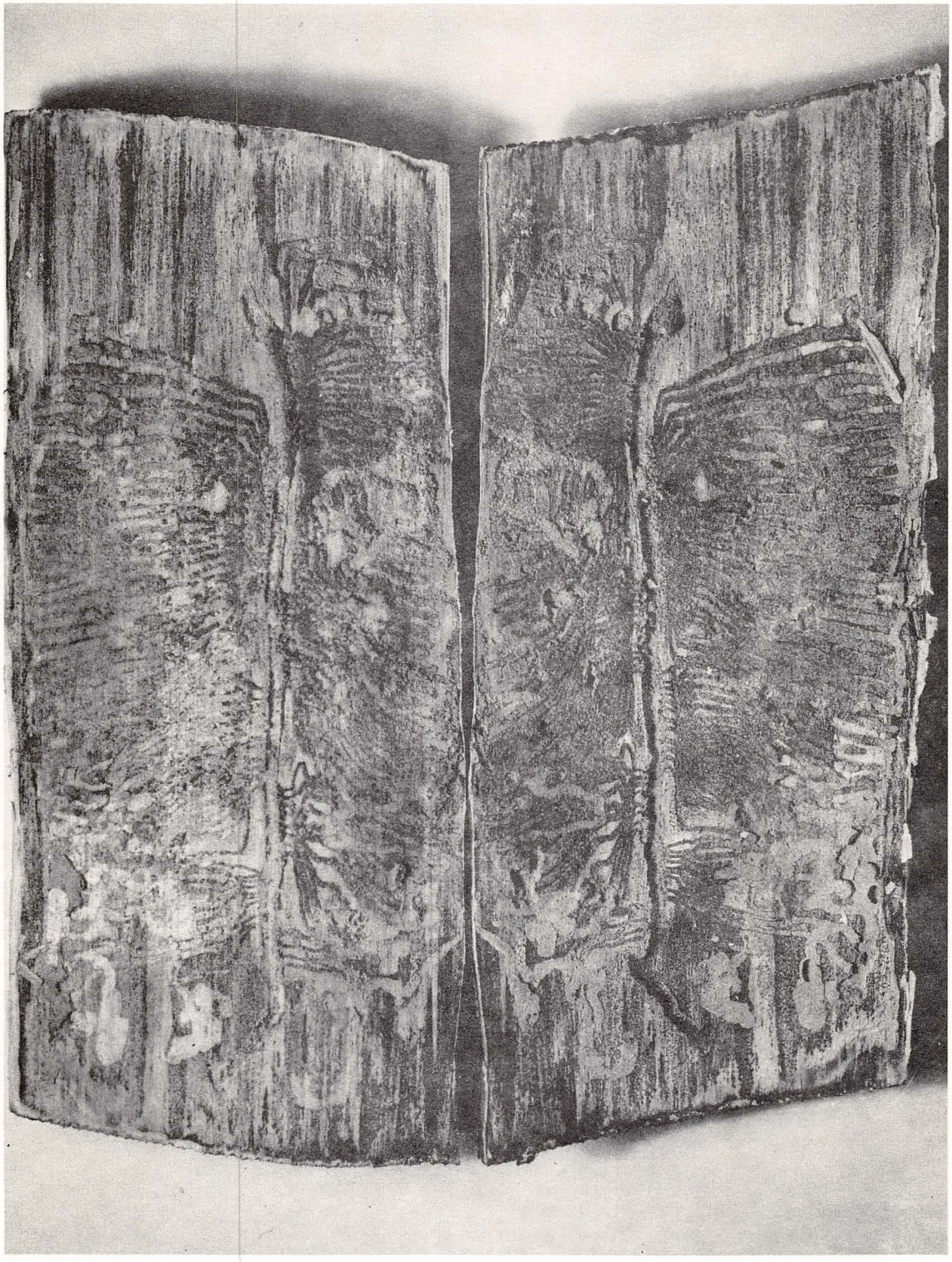

Fig. 4. – Ten-inch test block with bark and wood separated to show the gallery produced by a female beetle after overwintering 3 months in the forest litter. The block was coated with paraffin to maintain a moisture content adequate for beetle activity.

felled. For those recommending salvage logging as a means of bark-beetle control, the results of this study should provide a convincing argument for the removal of infested material from the woods as soon as possible.

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